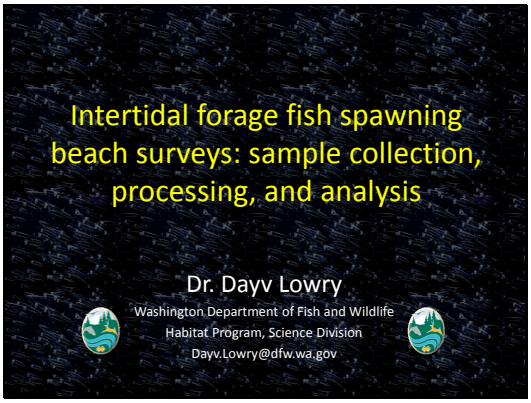
Slide 1



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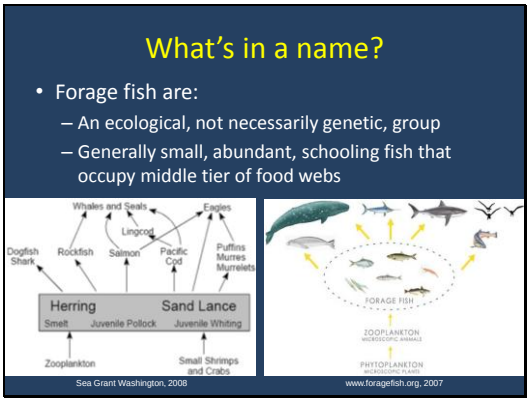
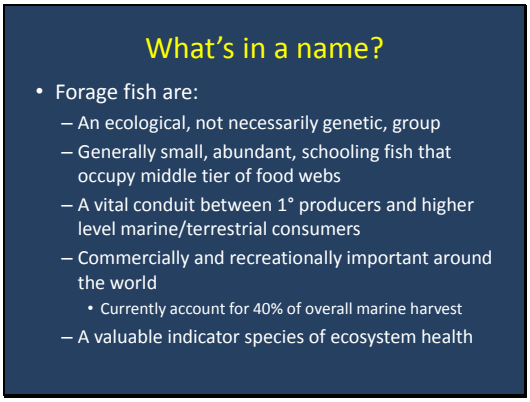


The term "forage fish" can be broadly applied to a diverse assemblage of species that are, in many cases, related through ecology and not phylogeny. Sometimes called "forage species," to include krill, squid, etc.

Many call forage fish the "fuel of marine food webs." Generally planktivores, consuming copepods, mysids, and diverse larval forms of other organisms.

Not necessarily keystone species (abundance is too high to meet strict definition).

Slide 3

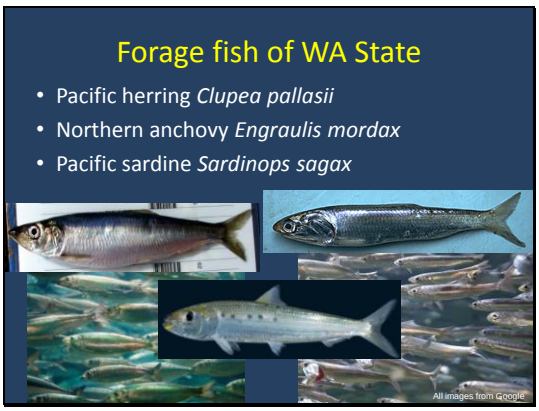


Importance of a given species may vary seasonally with changes in energy content (associated with spawning).

Sardine, anchovy, and herring fisheries, among others, dominate fisheries catch around the world (by mass).

Schooling makes them vulnerable to overfishing, habitat use and physiology makes them sensitive to disturbance in the nearshore. Together, this makes forage fish a good indicator of the overall health of the ecosystem.

Slide 4



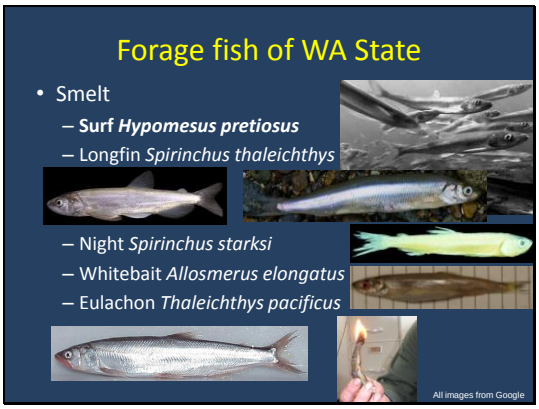
Commercial harvest of herring in Puget Sound is for bait and averages 300-400 metric tons annually.

The Cherry Point herring stock was petitioned for ESA listing in 2004. The stock was determined to be part of the Georgia Basin Distinct Population Segment (DPS) and, thus, not a "species" for ESA purposes. ESA status is Not Warranted.

Anchovy are also harvested commercially, but very few landings in recent years. Substantial populations may exist in South Puget Sound.

Sardine are fished on the outer coast, mostly outside Grays Harbor. 4000-8000 metric tons taken from 2004-2009. Moved from emerging to standard fishery in 2009.

Slide 5

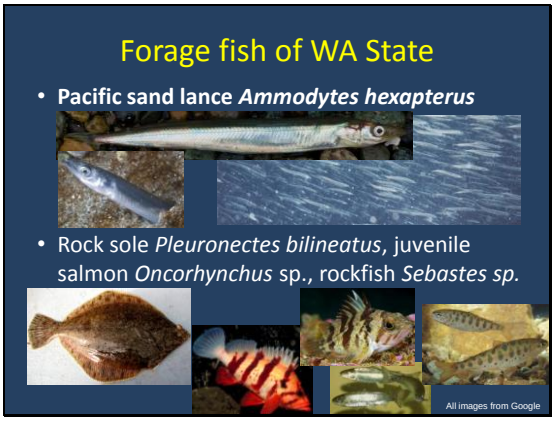


Surf smelt are best known and studied, specifically with regard to spawning locations, of the smelt in Washington, though there is still much we don't know. Recent genetic work suggests a single stock in Puget Sound, despite clear summer, winter, and year-round spawning behavior in different regions.

Marine populations of longfin, night, and whitebait smelt are little known. Well-studied *freshwater* longfin population in Lake Washington. Longfin populations are known from the Nooksack River and lower Columbia. Night smelt may comingle with surf smelt in schools and spawn on the same beaches.

The Southern DPS of Eulachon were ESA listed as threatened in 2010. Populations in the Columbia (Cowlitz River) and Strait of Juan de Fuca (Elwha River) are included in listing, in addition to those in OR, CA, and southern half of BC (south of Nass River).

Slide 6

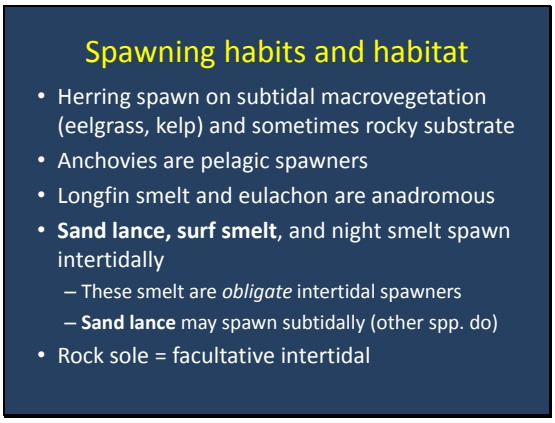


Despite only knowing about their intertidal spawning behavior since the 1980s, sand lance spawning locations are relatively well studied. Little else is known about their distribution, though recent work in San Juans on submarine sand wave fields is advancing knowledge considerable. Also recent work by 5th Life Productions documenting spawning behavior (dramatic!).

Various other species are considered "forage species" at specific life history stages, in discrete areas, or relative to specific predators. This definition is biological/ecological, and these species are not defined as "forage fish" in Washington state statute.

Rock sole spawning has mostly been document in extreme South Sound, with isolated occurrences elsewhere.

Slide 7



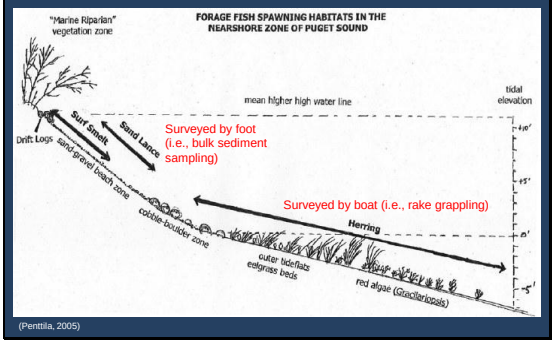
As several families of fish are "forage fish," it should come as no surprise that the spawning behavior and habitats of species differ. Even within a family, e.g., the smelts, spawning can differ substantially.

Most longfin smelt and eulachon die after spawning, but this has not been recorded for surf smelt and night smelt. These species may move offshore then die, but we have no strong evidence to support death or survival after spawning.

Species of sand lance other than the one found in WA are known to spawn exclusively subtidally and some evidence suggests *A. hexapterus* may.

Slide 8

Use of Puget Sound beaches



(Penttila, 2005)

The portion of the beach utilized by a given species dictates the survey methods that may be used to detect/quantify spawning. Subtidal spawning requires boats or scuba divers, while intertidal spawning can be assessed when the tide is right.

Slide 9

Spawning beach attributes

- Surf smelt (and night smelt?):
  - Spawn from +7 ft tidal elev. to extreme high water
  - Prefer sand/gravel mix, most sediment in 1-7 mm diameter size range
  - Spawn depth 1-10 cm (coincides with sediment)
  - Tend to spawn toward center of drift cells
  - Riparian shade is critical, especially in summer
    - Helps regulate temperature and relative humidity
  - Beyond basic requirements spawning is limited by access to beach; fairly widespread

Each species has requirements and preferences for selecting a spawning beach. These may overlap among species and co-occurrence on a given beach is not uncommon.

Slide 10

Surf smelt spawning beach

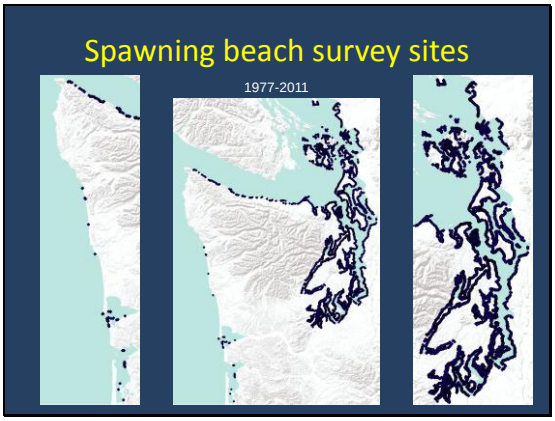
- Marrowstone Island, near Marine Station

Photos: D. Noviello

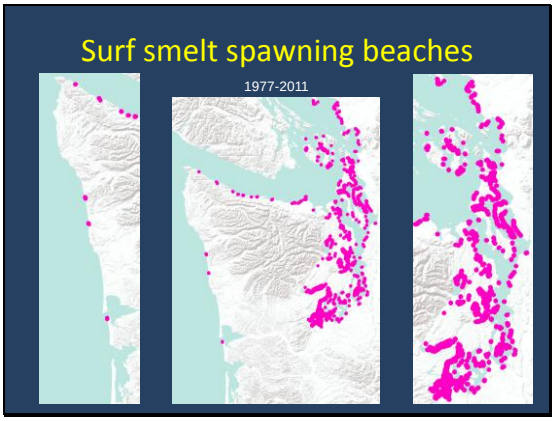
Note that the grain size of the beach appears larger, even at this scale, than prior pictures of sand lance beaches.

Slide 11

Slide 12



Slide 13



Slide 14

Spawning beach attributes

- Sand lance:
  - Spawn from +5 ft up to MHHW (and subtidally?)
  - Prefer sand, most sediment in 0.2-0.4 mm diameter size range
  - Tend to spawn toward distal ends of drift cells
  - Riparian shade not critical
    - Tend to spawn in winter
    - Tend to spawn lower on beach = more water coverage
  - Because they may spawn subtidally, beach surveys may not reflect total spawning area

Slide 15

Sand lance spawning beach

- South Port Gamble Bay – note spawning pits

Photo: D. Penttila

Yellow cups indicate elevation of spawning band – note it is relatively low compared to the high water mark.

Slide 16

Spawning pit detail

- 6-10 inches in diameter
- Generated by female digging

Photo: D. Penttila

Slide 17

Sand lance spawning beach

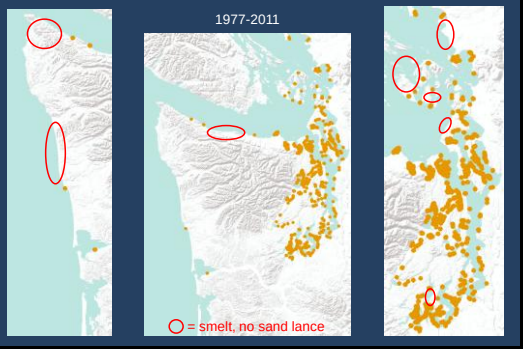
- Miller Bay Spit, Kitsap Co.
  - Note lack of vegetation, low slope, "muddiness"

Photo: D. Penttila

Note that at this site there is effectively no riparian shading, as opposed to the site two slides prior to this.

Slide 18

Sand lance spawning beaches



Slide 19

Spawning site importance/protection

- Location makes them vulnerable to shoreline development and other human actions
  - Spatial/temporal distribution incompletely known
  - Already significant loss, what remains *must* remain
- WDFW Hydraulic code (WAC 220-110) has "no net loss" provision for forage fish spawn sites
  - Incorporated into shoreline master programs and critical area ordinances to afford protection
- Public education and involvement is key!

Spawning intertidally is physiologically demanding, but may provide a release from predation pressure. However, it opens up a whole new world of impacts from human development.

Slide 20

Goals of spawning beach surveys

- Presence/absence surveys for new spawning areas, or to verify known sites
  - Must have full seasonal coverage, ultimately
- Quantitative evaluations of spawn abundance and specific timing
  - Requires extensive lab processing time/expertise
- Scientific evaluations of site preference, correlated variables, genetic structure of populations, identification of "new" species

The **reason** a specific beach is surveyed using the methods described below varies depending on who is doing the survey.

Slide 21

Goals of spawning beach surveys

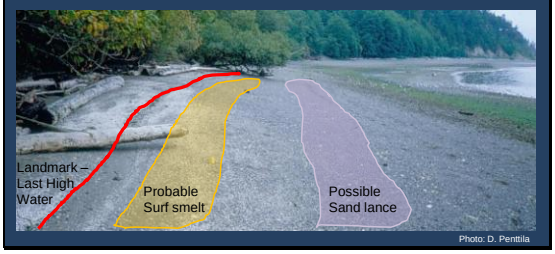
- Survey site selection can be driven by:
  - Exploratory investigation for presence
  - Nearshore construction permits (HPA application)
  - Comparison with historic work, or convenience
- **Before sampling the goal should be clear.**
  - Exact location depends on species of interest, sample processing varies based on question
- Sample at lowest feasible tide
  - Seasonal issues arise; may need night sampling

The **specific location** for a survey can be dictated by several things, but a clear goal is critical to effective sampling.

Slide 22

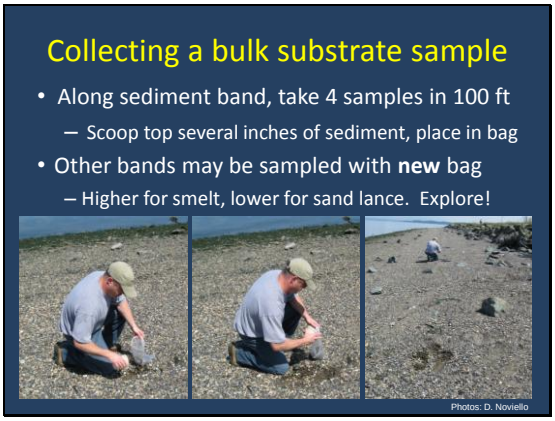
Site overview and initial data

- Once on site: record GPS fix, identify band of spawning gravel, note landmark, and record attributes of beach/upland (see data form)



Standard data sheets are provided by WDFW for use in conducting forage fish spawning beach surveys. The "header" information on the form is critical to being able to integrate the data into the overall database information scheme, as are several subjectively scored attributes of the beach.

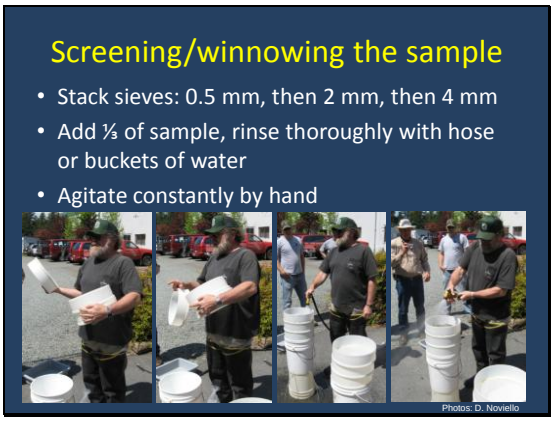
Slide 23



Length of transect along sediment band can be measured, or you can use the rule of thumb that a sample (i.e., scoop) is taken at a location, then 10 single paces* away, then 10 more paces, then 10 final paces. As a single pace for most adults is a little over 3 ft, 10 paces = approximately 30 feet.

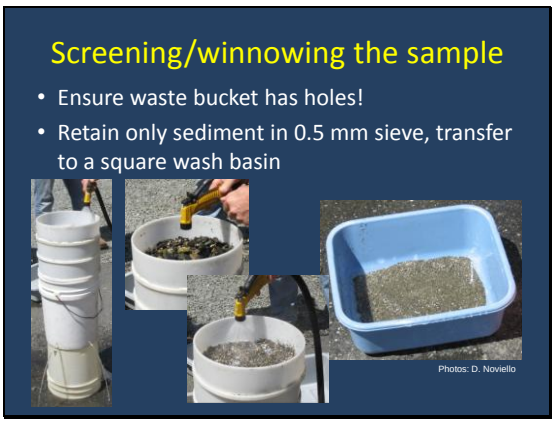
* A single pace as described here is the distance, when walking, between the heel of one foot and the heel of the other foot as they strike the ground.

Slide 24



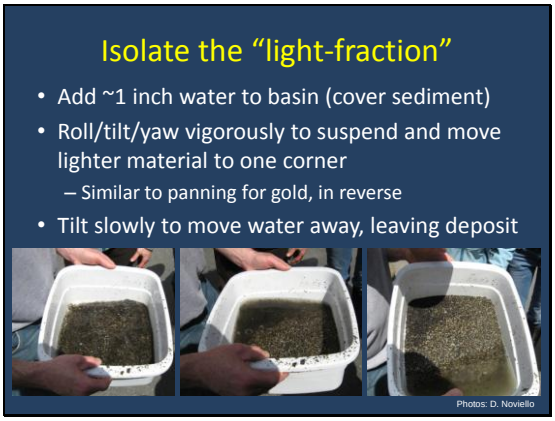
Stainless steel, or Nalgene if you can find them, sieves are recommended over brass for durability.

Slide 25



Round wash basins do not work, you need corners to isolate the lighter material. The deeper the square basin, the better.

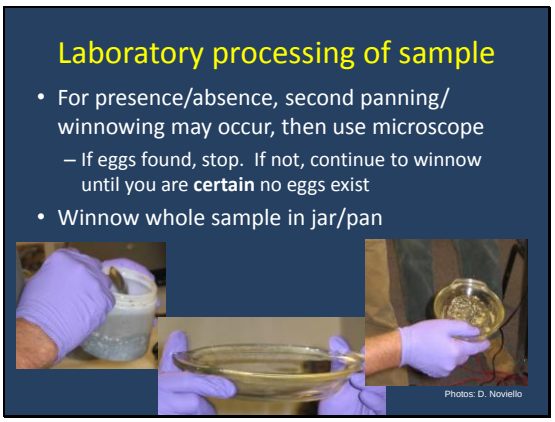
Slide 26



When panning for gold, the material of interest is heavy and will settle first whereas when winnowing for eggs the material of interest is lighter than the sediment and will suspend in the water or move to the top of the sample during agitation.

Slide 27

Slide 28



Second winnowing is performed to maximize egg return and minimize microscope time when a simple “yes/no” is the goal. Ultimately the whole sample may be gone through if eggs are not found in the first several subsamplings.

A “no” is only a *definitive* “no” once the entire sample has been examined. Even then a “no” should be interpreted with caution unless you are certain the proper tidal elevation was sampled. If in doubt, survey more transects in the field.

Slide 29

Laboratory processing of sample

- For quantitative assessment of egg density (esp. high density), process lengthier
  - Sample must be thoroughly dried and weighed
  - Mix sample well, then subsample and count eggs
  - Estimate total egg abundance and eggs/gram dry substrate from a minimum of **3** subsamples

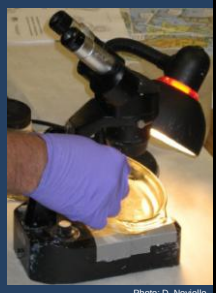


Photo: D. Noviello

A standardized protocol describing the details of this technique is available from WDFW.

Note that the goal here is not to maximize egg return from a single sample (i.e., no second winnowing) but to representatively survey the sample without having to examine the entire thing.

Slide 30

Examples of eggs found

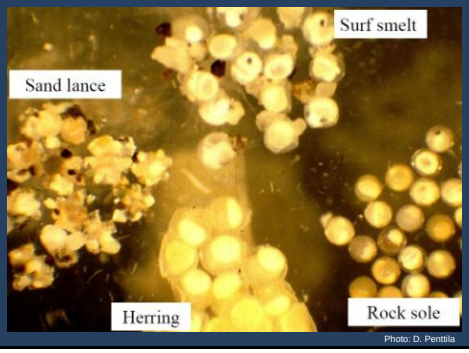


Photo: D. Penttila

Surf smelt eggs have a pedicle (=single attachment "stalk"), while sand lance eggs are usually surrounded with grains of sand.

Herring eggs are larger than sand lance or surf smelt eggs, self-adhesive, occur in clumps, and are typically attached to vegetation not found in the sand.

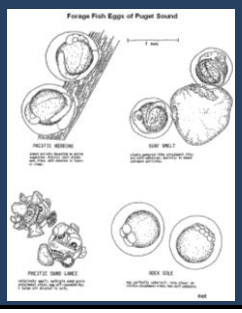
Rock sole eggs are perfectly spherical, non self-adhesive, and have no attachment site.

Anchovy eggs are oval, and they float.

Slide 31

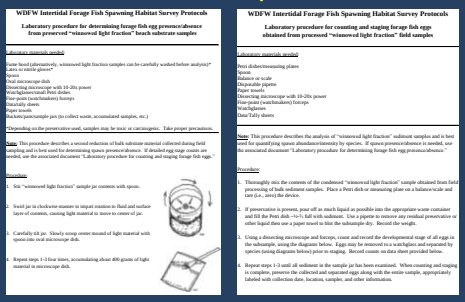
Identification guides

- Provided as handouts on request, web soon



Slide 32

Standardized protocols



WDFW Intertidal Forage Fish Spawning Habitat Survey Protocols

Laboratory procedure for determining forage fish egg presence/absence from preserved "winnowed light fraction" beach substrate samples

Laboratory materials needed

Fume hood (alternatively, winnowed light fraction samples can be carefully washed before analysis)*
Gloves or nitrile glasses*
Spoon
Dual microscope dish
Dissecting microscope with 10-20x power
Watchglasses/small Petri dishes
Fine-point (watchmakers) forceps
Waterfully sheets
Paper towels
Buckets/jars/sample jars (to collect waste, accumulated samples, etc.)

*Depending on the preservative used, samples may be toxic or carcinogenic. Take proper precautions.

Note: This procedure describes a second reduction of bulk substrate material collected during field sampling and is best used for determining spawn presence/absence. If detailed egg stage counts are needed, use the associated document "Laboratory procedure for counting and staging forage fish eggs."

Procedure

1. Stir "winnowed light fraction" sample jar contents with spoon.
2. Swirl jar in clockwise manner to impart rotation to fluid and surface layer of contents, causing light material to move to center of jar.
3. Carefully tilt jar. Slowly scoop center mound of light material with spoon into oval microscope dish.
4. Repeat steps 1-3 four times, accumulating about 400 grams of light material in microscope dish.

WDFW Intertidal Forage Fish Spawning Habitat Survey Protocols

Laboratory procedure for counting and staging forage fish eggs obtained from processed "winnowed light fraction" field samples

Laboratory materials needed

Petri dishes/measuring plates
Spoon
Balance or scale
Disposable pipette
Paper towels
Dissecting microscope with 10-20x power
Fine-point (watchmakers) forceps
Watchglasses
Data/Tally sheets

Note: This procedure describes the analysis of "winnowed light fraction" sediment samples and is best used for quantifying spawn abundance/intensity by species. If spawn presence/absence is needed, use the associated document "Laboratory procedure for determining forage fish egg presence/absence."

Procedure

1. Thoroughly mix the contents of the condensed "winnowed light fraction" sample obtained from field processing of bulk sediment samples. Place a Petri dish or measuring plate on a balance/scale and tare (i.e., zero) the device.
2. If preservative is present, pour off as much liquid as possible into the appropriate waste container and fill the Petri dish ¼-½ full with sediment. Use a pipette to remove any residual preservative or other liquid then use a paper towel to blot the subsample dry. Record the weight.
3. Using a dissecting microscope and forceps, count and record the developmental stage of all eggs in the subsample, using the diagrams below. Eggs may be removed to a watchglass and separated by species (using diagrams below) prior to staging. Record counts on data sheet provided below.
4. Repeat steps 1-3 until all sediment in the sample jar has been examined. When counting and staging is complete, preserve the collected and separated eggs along with the entire sample, appropriately labeled with collection date, location, sampler, and other information.

- Sampling manual: Moulton and Penttila (2001, 6)

Moulton and Penttila (2001) was revised in 2006.

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Further contact/training/support

- Web-based "refresher course" available
  - Contains presentation, sampling protocols, identification guides, and other materials
  - Group training can consist of hybrid on-line/in-person training, or all face-to-face
- Egg samples for ID, etc. can be sent to Olympia
- **Data for completed surveys → WDFW, please**
- For training or consulting contact Dayv Lowry, WDFW, Habitat Science Division
  - Dayv.Lowry@dfw.wa.gov; 360-902-2558

IMPORTANT NOTE: Any beach survey conducted without WDFW staff present requires a Scientific Collection Permit (Bruce Baker, WDFW) or a written Memorandum of Understanding. The MOU is easier to obtain and can be generated with several days notice of a survey. An MOU can also cover longer term projects.